

Remarks

Claims 1-17 are pending herein. By this Amendment, the specification has been amended and new claims 15-17 have been added. A deposit account payment of \$150 for the three added claims is submitted with this Amendment.

The specification has been amended to correct a minor misspelling.

New claims 15-17 depend upon claims 1, 3 and 12, respectively, and positively recite the presence of hydrogen atoms. Specifically, claim 15 recites that the fluoridation carbon film in the semiconductor device of claim 1 comprises more than 0 atomic % of said hydrogen atoms. Claim 16 recites that in the manufacturing method of claim 3, the source gas includes more than 0 atomic % of said hydrogen atoms, and the fluoridation carbon film includes more than 0 atomic % of said hydrogen atoms. Claim 17 recites that the gas recited in claim 12 comprises more than 0 atomic % of said hydrogen atoms.

Applicants submit that support for the recitation “more than 0 atomic %” in the new claims is inherently present in the recitation “3 atomic % or less” set forth in claims 1, 3 and 12.

In the Office Action, claims 1-5 and 12 are rejected under 35 U.S.C. §102(b) as being anticipated by U.S. Patent No. 5,989,998 to Sugahara et al. (“Sugahara”); claims 6, 7 and 9-11 are rejected under 35 U.S.C. §103(a) as being unpatentable over Sugahara in view of U.S. Patent No. 6,035,803 to Robles et al. (“Robles”); claim 8 is rejected under §103(a) as being unpatentable over Sugahara in view of Robles as applied to claim 6 above, and further in view of U.S. Patent No. 5,661,093 to Ravi et al. (“Ravi”); and claims 13 and 14 are rejected under §103(a) as being unpatentable over Sugahara in view of Ravi.

In view of the remarks herein, Applicants respectfully request reconsideration and withdrawal of the rejections set forth in the Office Action.

I. Rejection of Claims 1-5 and 12

As noted above, claims 1-5 and 12 are rejected under 35 U.S.C. §102(b) as being anticipated by Sugahara.

Sugahara is cited in part for teaching an interlayer insulating film that is a fluorinated amorphous carbon film formed by inducing plasma polymerization of a material having, as a main component, hexafluoropropene which is a fluorinated carbon compound having a double bond of carbon atoms in a molecule thereof and containing no hydrogen atom (col. 13, lines 12-20). Sugahara states that because the hexafluoropropene contains no hydrogen atom, the resulting interlayer insulating film is a fluorinated amorphous carbon film containing only carbon and fluorine atoms (col. 13, lines 27-30). The reference further discloses that to evaluate the heat resistance of the interlayer insulating film, the semiconductor substrate formed with the fluorinated amorphous carbon film was held at a temperature of 400°C. in vacuum for 1 hour (col. 13, lines 37-41).

As to claim 12, Sugahara is cited for teaching an interlayer insulating film that is a fluorinated amorphous carbon film formed by inducing plasma polymerization of a material having, as a main component, hexafluoro-1,3-butadiene which is a fluorinated compound having two double bonds of carbon atoms in a molecule thereof and containing no hydrogen atom (col. 13, lines 59-65).

Applicants respectfully submit that Sugahara does not anticipate claims 1-5 and 12.

Applicants' invention relates to the technique of forming a fluoridation carbon film that contains 3 atomic % or less of hydrogen atoms. Such film is formed, for example, by using a source gas that contains substantially no impurity hydrogen atoms.

In the portions thereof cited in the Office Action, Sugahara states that the fluorinated carbon compound subjected to plasma polymerization contains no hydrogen atom. However, Applicants respectfully submit that even if a source gas consists of a chemical compound including no hydrogen, a small amount of hydrogen necessarily exists in the source gas as an impurity in the form of water that has not completely been removed. When a fluoridation carbon film is formed by using the source gas including the small amount of hydrogen as impurities, the formed film necessarily includes a large amount of hydrogen atoms even if the amount of impurity hydrogen in the gas is small. In the subsequent thermal process, the large amount of hydrogen atoms in the film results in weight reduction of the film.

Applicants found that if the amount of hydrogen included in the formed film is 3 atomic % or less, the weight reduction of the formed film can be prevented in the subsequent thermal process. This is the essential feature of the present invention.

On the other hand, Sugahara teaches that a formed fluorinated amorphous carbon film does not include hydrogen because the fluorinated amorphous carbon film is formed by using a fluorinated carbon compound. This is the same disclosure as that of JP-A-144675/1998, JP-A-237783/1997 and JP-A-220668/2002, which are cited as background art in the instant specification. However, Sugahara does not teach or suggest whether the source gas may contain a hydrogen-containing impurity, e.g., water, and what amounts of such impurity may be present in the source gas.

A novel finding of the Applicants is that even if a compound including no hydrogen is used in the source gas, impurity hydrogen atoms as water are necessarily contained in the gas used in practice in the industry, resulting in a large amount of hydrogen content in the formed film.

Applicants submit that those skilled in the art, based on the disclosures in the aforementioned JP-A-144675/1998, JP-A-237783/1997 and JP-A-220668/2002 and further based on source gases used in actual practice in the industry, would understand that the Sugahara source gas may in fact contain hydrogen atoms in the form of water (i.e., as an impurity rather than as an intentional ingredient). However, Suguhara does not recognize this issue or teach how to deal with such issue in making semiconductor devices. In other words, those skilled in the art would not rely on Suguhara to overcome problems associated with the presence of even small amounts of hydrogen impurities in the source gas or fluoridation carbon film. As noted above, a key feature of the present invention is Applicants' discovery that if the amount of hydrogen included in the formed film is 3 atomic % or less, the weight reduction of the formed film can be prevented in the subsequent thermal process. This is not taught or suggested in Sugahara.

Based on the foregoing comments, Applicants respectfully submit that Sugahara does not anticipate or render obvious instant claims 1-5 and 12 or new claims 15-17.

II. Rejection of Claims 6, 7 and 9-11

Claims 6, 7 and 9-11 are rejected under 35 U.S.C. §103(a) as being unpatentable over Sugahara in view of Robles.

The Office Action notes that Sugahara is silent regarding the concentration of the chemical compound including the hydrogen atom. Robles is cited for disclosing that lowering the concentration of the chemical compound including the hydrogen atom lowers the dielectric constant of the insulating film. According to the Office Action, it would have been obvious to use a lower concentration of the chemical compound including the hydrogen atom, such as 90 ppm or less, so as to produce an insulating film having a desirably low dielectric constant.

Applicants respectfully submit that claims 6, 7 and 9-11 would not have been obvious over Sugahara in view of Robles.

Robles discloses that a halogen-doped carbon-based layer is formed by using a CH₄ gas and a C₄F₈ gas which purportedly includes hydrogen. However, it is the undersigned's understanding that the film obtained from such CH₄ gas includes hydrogen in an amount significantly higher than 90 weight ppm.

Therefore, the modification of Sugahara in view of Robles would result in a much higher amount of hydrogen atoms.

Sugahara teaches that the use of a fluorinated carbon compound composed only of carbon atoms and fluorine atoms prevents the plasma polymerization film from containing hydrogen, thereby resulting in the dielectric constant of the resulting interlayer insulating film being lowered (see, e.g., col. 4, lines 40-45). Robles does not teach or suggest a connection between the amount of hydrogen atoms present in the film and the dielectric constant of the film. Applicants submit that in view of the aforementioned teaching in Sugahara and Robles' failure to teach or suggest a connection between the amount of hydrogen atoms present in the film and the dielectric constant of the film, one skilled in the art would not be motivated by Robles to add any amount of a hydrogen-containing compound to those embodiments in Sugahara that use a fluorinated carbon compound containing no hydrogen atoms.

Thus, for at least the foregoing reasons, Applicants respectfully submit that claims 6, 7 and 9-11 would not have been obvious over Sugahara in view of Robles.

III. Rejection of Claim 8

Claim 8 is rejected under §103(a) as being unpatentable over Sugahara in view of Robles as applied to claim 6 above, and further in view of Ravi.

According to the Office Action, Sugahara in view of Robles is silent regarding the concentration of water. Ravi is cited for teaching that the presence of water increases the dielectric constant of an insulating film. The Office Action states that it would have been obvious to use a concentration of water of 3 ppm by weight or less so as not to undesirably increase the dielectric constant of the insulating film.

Ravi relates to a fluorine-doped silicon glass (FSG) rather than to a fluoridation carbon film. Thus, Applicants submit that Ravi would not motivate one skilled in the art to modify a method for making or using a fluoridation carbon film.

As noted above, Sugahara teaches that the use of a fluorinated carbon compound composed only of carbon atoms and fluorine atoms prevents the plasma polymerization film from containing hydrogen, thereby resulting in the dielectric constant of the resulting interlayer insulating film being lowered. Robles is directed to a process for depositing a dielectric film having a reduced dielectric constant (see, e.g., Abstract). Ravi is directed to a method and apparatus for depositing a halogen-doped oxide film having a low dielectric constant. Applicants respectfully submit that one skilled in the art would not be motivated by Ravi to modify Sugahara in view of Robles in any way that might result in an increased dielectric constant. Thus, Applicants submit that one skilled in the art would not be motivated to use water in the method of Sugahara.

Therefore, for at least the foregoing reasons, Applicants respectfully submit that claim 8 would not have been obvious over Sugahara in view of Robles and further in view of Ravi.

IV. Rejection of Claims 13 and 14

Claims 13 and 14 are rejected under §103(a) as being unpatentable over Sugahara in view of Ravi.

Sugahara and Ravi are cited for the same reasons given in connection with the rejection of claim 8.

As discussed above, Sugahara and Ravi are both directed to methods for making films having a low dielectric constant. In view of this, Applicants submit that that one skilled in the art would not be motivated by Ravi to modify Sugahara in any way that might result in an increased dielectric constant. Thus, Applicants submit that one skilled in the art would not be motivated to use water in the method of Sugahara.

Therefore, for at least the foregoing reason, Applicants respectfully submit that claims 13 and 14 would not have been obvious over Sugahara in view of Ravi.

V. Conclusion

In view of the remarks herein, Applicants respectfully request that the rejections set forth in the Office Action be withdrawn and that claims 1-17 be allowed.

If any additional fees under 37 C. F. R. §§ 1.16 or 1.17 are due in connection with this filing, please charge the fees to Deposit Account No. 02-4300, Order No. 033082M300.

Respectfully submitted,
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Dated: September 28, 2007

MAM/MM/cj

Enclosure: Petition for Extension of Time